

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions and listings of claims in the application:

LISTING OF CLAIMS:

1. (currently amended): A vehicle running state estimation method comprising:
detecting a vibration level of a portion below a spring of a running vehicle; and
estimating the running state of the vehicle as a whole by determining at least one of a condition of a road surface on which the vehicle is running and a running state of each tire, wherein said determining is based on the detected vibration level.
2. (currently amended): A vehicle running state estimation method comprising:
detecting a vibration level of a portion below a spring of a running vehicle; and
estimating the running state of the vehicle by determining at least one of a
condition of a road surface on which the vehicle is running and a running state of each tire,
wherein said determining is based on the detected vibration level, and ~~The vehicle~~
~~running state estimation method according to claim 1,~~ wherein a waveform of time changes in the vibration level is detected and the condition of the road surface on which the vehicle is running is estimated from a vibration level at a predetermined position of the waveform or for a predetermined time range.

3. (previously presented): The vehicle running state estimation method according to claim 1, wherein a frequency of the detected vibration level is analyzed to calculate a vibration level at a predetermined frequency band and the condition of the road surface is estimated from the calculated vibration level.

4. (previously presented): The vehicle running state estimation method according to claim 1, wherein the frequency of the detected vibration level is analyzed, at least two vibration levels at different frequency bands are calculated, an operation is carried out on the at least two calculated vibration levels, and the condition of the road surface is estimated from computed value.

5. (previously presented): The vehicle running state estimation method according to claim 1, wherein vibration levels of at least two points of a portion below the spring are detected to calculate a vibration transmission level of the portion below the spring, and the condition of the road surface is estimated from the calculated vibration transmission level.

6. (previously presented): A vehicle running state estimation apparatus for estimating running state of a vehicle based on road surface conditions, the estimation apparatus comprising:

means of detecting a vibration level of a portion below a spring of a running vehicle;

means of computing waveform of time changes in the vibration level; and

road surface condition estimation means for estimating a condition of a road surface on which the vehicle is running from the vibration level at a predetermined position of the waveform or for a predetermined time range.

7. (previously presented): The vehicle running state estimation apparatus according to claim 6 further comprising means of calculating the vibration level of at least one of a tire leading edge portion, tire ground contact portion and tire trailing edge portion of the waveform.

8. (previously presented): A vehicle running state estimation apparatus comprising:

means of detecting a vibration level of a portion below a spring of a running vehicle;

means of calculating a vibration level at a predetermined frequency band by analyzing frequency of the detected vibration level; and

road surface condition estimation means for estimating the condition of the road surface on which the vehicle is running from the calculated vibration level,

wherein the running state of the vehicle is estimated based on the condition of the road surface received from the road surface condition estimation means.

9. (previously presented): A vehicle running state estimation apparatus comprising:

means of detecting a vibration level of a portion below a spring of a running vehicle; and

road surface condition estimation means for estimating condition of a road surface from a value obtained by carrying out an operation on at least two vibration levels at different frequency bands by analyzing the frequency of the detected vibration level,

wherein the running state of the vehicle is estimated based on the condition of the road surface received from the road surface condition estimation means.

10. (currently amended): A vehicle running state estimation apparatus for estimating a running state of a vehicle based on a condition of a road surface comprising:

means of detecting vibration levels of at least two points on a portion of a tire below a spring of the running vehicle;

means of calculating a vibration transmission level at a predetermined frequency band between said at least two vibration detection points; and

road surface condition estimation means for estimating the condition of the road surface on which the vehicle is running from the calculated vibration transmission level.

11. (previously presented): The vehicle running state estimation apparatus according to claim 10, wherein a vibration buffer member is interposed between said at least two vibration detection points.

12. (previously presented): The vehicle running state estimation apparatus according to claim 8, wherein a road surface friction coefficient μ at a time of running the vehicle is estimated based on a relationship between a surface friction coefficient μ obtained from braking distances of the vehicle under various road conditions at different speeds and at least one of the calculated vibration level at saidpredetermined frequency band and a calculated vibration transmission level .

13. (previously presented): The vehicle running state estimation apparatus according to claim 8, wherein the frequency band is a band including frequency of natural vibration of a tire tread land portion.

14. (previously presented): The vehicle running state estimation apparatus according to claim 8, wherein a threshold value is set for the vibration level, and the surface of the road is estimated to be in a low friction condition when the calculated vibration level exceeds the threshold value.

15. (previously presented): The vehicle running state estimation apparatus according to claim 14, wherein the threshold value can be changed.

16. (previously presented): The vehicle running state estimation apparatus according to claim 6 which further comprises a vehicle speed detection means to estimate the condition of a road surface based on vehicle speed.

17. (previously presented): The vehicle running state estimation apparatus of claim 6, further comprising:

means of judging slipperiness of the road surface based on the condition of the road surface estimated by the road surface condition estimation means; and

warning means for giving a warning when it is judged that the condition of the road surface is slippery.

18. (previously presented): The vehicle running state estimation apparatus according to claim 17, further comprising:

vehicle speed detection means to change decision on the slipperiness of the road surface and warning level based on vehicle speed.

19 - 24. (canceled).

25. (previously presented): The vehicle running state estimation apparatus according to claim 6, further comprising a transmitter for transmitting output of the vibration detection

means for calculating a time change in the vibration level or a vibration level at a predetermined frequency band.

26. (previously presented): The vehicle running state estimation apparatus according to claim 6 further comprising a power generating unit mounted on a tire wheel, wherein the power generating unit generates power by rolling of each tire and supplies power for at least one of driving the vibration detection means and amplifying output of the vibration detection means.

27. (previously presented): A vehicle control apparatus comprising vehicle control means for controlling the running state of a vehicle based on the condition of the road surface estimated by the vehicle running state estimation apparatus of claim 6.

28. (previously presented): The vehicle control apparatus according to claim 27 which comprises vehicle speed detection means to control the running state of the vehicle based on vehicle speed.

29. (previously presented): The vehicle control apparatus according to claim 27, wherein the vehicle control means controls locked state of each wheel.

30. (previously presented): The vehicle control apparatus according to claim 27, wherein the vehicle control means controls attitude of the vehicle.

31. (previously presented): The vehicle control apparatus according to claim 27, wherein the vehicle control means controls air pressure of each tire.

32. (previously presented): The vehicle control apparatus according to claim 27, wherein the vehicle control means controls idling state of each wheel.

33. (previously presented): The vehicle control apparatus according to claim 27, wherein the vehicle control means changes inter-vehicle distance set value of an automatic driving system.

34. (previously presented): A tire wheel comprising: the vehicle running state estimation apparatus for estimating a running state of the vehicle by detecting the vibration level of the portion below the spring as set forth in claim 6, and a power generating unit for generating power by a rolling of each tire and supplying power to the estimation apparatus.

35. (original): The tire wheel according to claim 34, wherein the vehicle running state estimation apparatus is mounted to the tire wheel.

36. (previously presented): The tire wheel according to claim 34, wherein the power generating unit comprises a rotor magnetized and rotated by the rolling of each tire, a stator made from a high magnetic permeability material and adjacent to the rotor and a power generating coil installed within a magnetic circuit including the rotor and the stator.

37. (original): The tire wheel according to claim 36, wherein the power generating unit comprises means of accumulating electromotive force generated in the power generating coil.

38. (previously presented): The tire wheel according to claim 36, wherein the rotor is turned by rotating an unbalance weight the gravity center of the rotary cone of which is eccentric to a rotary shaft by the rolling of each tire.

39. (previously presented): The tire wheel according to claim 36, wherein an air stream generated by the rolling of each tire is introduced into the power generating unit and the rotor is turned by the introduced air stream.